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This is a very interesting paper which suggests that renewable energy sources might by 2025 produce a 20% reduction in the UK's CO₂ emissions. A summary is at the front but you may like to read through the paper. I've flagged up some particularly interesting passages.

CBS

29/6

28 June 1990

Dear Caroline,

NEW ENERGY TECHNOLOGIES: RENEWABLES AND COAL

At MISC 141 on 6 March, following a discussion on the Department's renewables and coal activities, my Department's Chief Scientist was asked to prepare a paper on new energy technologies reviewing the achievements and placing them in an international context. The paper was to be prepared in consultation with SERC. (MISC 141 (1990) 3rd meeting, Minute 3). I attach the text of such a paper on which we have consulted SERC. The summary describes its main conclusions.

We have reviewed the Department's programmes in these areas in the context of developing the energy contribution to the environment White Paper. The texts we have provided for DOE (which I understand will be circulated in MISC 145 shortly) will therefore reflect the Department's broad views on their future. In both cases however the programmes will be subject to review during the course of next year and some redefinition of their overall strategy may be required in the light of developments in the Government's policy on the greenhouse effect and other environmental challenges.

I am copying this to private secretaries to members of MISC 141.

Yours sincerely

Terry Carrington

TERRY CARRINGTON
Private Secretary

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NEW ENERGY TECHNOLOGIES: RENEWABLE ENERGY AND COAL
RESULTS OF GOVERNMENT PROGRAMMES

SUMMARY

1. The Department's programmes in renewables and coal over the last decade have achieved a number of significant advances.

2. In Renewables:

- i. the technical potentials for energy supply for the UK of the various renewables have been identified and work concentrated on the most promising
- ii. a number of institutional barriers to the use of renewable energy have been identified and overcome to enable it to compete on an equal footing with conventional sources
- iii. a number of technologies have been brought to the point of being economic (eg landfill gas, passive solar design of buildings) and are being taken up in the market. R&D is continuing on a number of others on threshold of being economic (eg wind, some waste and biofuels). The non fossil fuel obligation for electricity generation provides a further spur to the development of such renewables.

For Coal

- i. new systems for clean coal combustion have been developed in collaboration with British Coal and others (eg fluidised bed combustion and new gasification technology). These have laid the foundations for new high efficiency low pollution coal based electricity generation systems for the 90s and beyond
 - ii. advances in the basic science of coal combustion have led to the development of improved burners currently being installed in power stations to reduce NOx emissions.
3. In the case of both technologies UK activities have taken place in the framework of international collaborations within the International Energy Agency and European Community and have taken advantage of work done abroad. The UK's programmes have achieved a very considerable amount by comparison with programmes in other countries, with relatively little expenditure.
4. Future activities in both areas will contribute to the achievement of reduced greenhouse gas emissions from the UK and work is currently under way to adapt the programmes to contribute in the most effective way.

NEW ENERGY TECHNOLOGIES:
RESULTS OF GOVERNMENT PROGRAMMES

Paper by Chief Scientist, Department of Energy

Programmes

The Department of Energy has supported R&D programmes in renewable and coal technology over the last 10-15 years. Expenditure on the programmes is set out at Annex 1.

2. In both Sectors the Department has pursued collaborations in particular areas with industry in the UK and with partners in other countries - either through bilateral collaboration or through multilateral arrangements in the International Energy Agency (a branch of OECD) or the European Community. Participation of officials from the Department in regular discussions in these organisations on R&D programmes in other countries ensures that the Department is kept fully informed about activities in other countries.

Renewables

3. The aim of the Department of Energy's renewables programme is to stimulate the development and application of renewable energy sources wherever they have prospects of being economically attractive and environmentally acceptable. This policy was published in 1988 in Energy Paper No 55 following a review of the first phase of the Department of Energy's renewable energy R&D programme. As there was originally little or no renewables industry one of the key

tasks for the Department is to develop a market for renewable energy.

Achievements: Phase I of the UK R&D Programme

4. The first phase of the Department's programme set out to define each renewable technology and estimate its costs, potential and possible contribution to the UK energy supplies. This work provided a comprehensive data base for renewable energy in the UK in contrast to the situation in many other industrialised countries. The review classified individual technologies as:

"Long Shot" where there were limited prospects of a significant economic contribution to UK energy supplies in the foreseeable future;

"Promising" where the technology was not yet commercially attractive but with identified R&D or rising prices had a reasonable prospect of becoming so;

"Economically Attractive" where the technology could be expected to achieve a commercial rate of return in at least some market sector.

Early on, the UK ceased significant volumes of work on the "Long Shot" technologies including large-scale offshore wave,

geothermal aquifers, and photovoltaics and focussed expenditure on the most promising areas.

Potential for Contribution from Renewables to UK Energy Supplies

5. The Phase I programme identified a technical potential for renewable energy larger than current UK energy requirements. However, most of this potential could not be developed commercially or within reasonable environmental constraints. The programme estimated a possible contribution from renewable energy by 2025 assuming that the identified R&D programme was successfully conducted and that fuel prices and economic trends continued on a steady forward path. The contribution estimated for electricity generation from renewable sources was up to nearly 70 Twh/yr and a further 5-17 million tonnes of coal equivalent (equivalent to nearly a quarter of current electricity supply) of current non-electricity energy use (between 2 and 7% of total UK non electricity energy use). The contributions from the individual technologies are shown in Table 1.

Current Strategy

6. The Department's activities on renewables currently cover two areas:

- A collaborative R,D&D programme with industry;

- The establishment of an institutional framework to ensure that renewables can compete in the market on equal terms with other energy sources.

TABLE 1

ESTIMATED ENERGY CONTRIBUTION AND CO2 EQUIVALENT SAVING BY 2025
FROM ENERGY PAPER 55

<u>Energy Source</u>	<u>Estimated Energy Contribution</u> (TWh/y)	<u>Estimated CO2 Equivalent Saving</u> (MtC/y)
<u>Electricity Producers</u>		
Wind Power:		
On Land	0 - 30	0 - <u>7.5</u>
Offshore	?	0
Tidal	0 - 28	0 - <u>7.0</u>
Geothermal HDR	0 - 10	0 - 2.5
Wave	0 - 0.2	0 - 0.05
Small-Scale Hydro	0.3 - 0.7	0.01 - 0.02
<u>Heat Producers</u>		
	(Mtce/y)	
Passive Solar	1 - 2	0.6 - 1.2
Biofuels:		
Wet and Dry Wastes	3 - 10	<u>5.8 - 16.0</u>
Forestry	1 - 5	0.6 - 3.0

Note:

1. Total current UK emission of CO2 is equivalent to 160 MtC/y.
2. It is assumed that methane emitted from landfill sites escapes to the atmosphere unless utilised as a fuel above.

7. The R&D programme is aimed:

- to stimulate exploitation of alternative energy resources in the UK where they are economic;
- establish and develop options for the future; and
- encourage the UK industry to develop capabilities for domestic and export markets.

The programme has moved from the basic assessment stage where it was almost totally funded by Government to a stage where industry is contributing approximately 25%. The strategy is for expenditure to peak during the mid-1990s with 50% funding from industry and then the Government contribution to fall to zero by the year 2000 with the expectation that technologies currently identified should be competitive by then. The Department of Energy's expenditure is currently running at around £20 million per year. A significant achievement of the programme has been to stimulate the development of an embryo renewable energy industry which can develop further during the 1990s and become self-sustaining from the year 2000 onwards.

8. The renewables programme is also addressing institutional barriers to the adoption of renewables and aims

to provide a suitable legislative framework and administrative for their future development. The main achievements to date have been:

- ensuring investment requirements for electricity generation from renewable energy sources are put on equal footing in the private sector with conventional generation and that renewables are treated in an equitable way alongside nuclear power under the Non-Fossil Fuel Obligation created under the Act to privatise the Electricity Industry;
- removing abstraction charges for water used to power small hydro electric schemes up to 5 MW capacity (via the Act to privatise the Water Industry);
- removing inequitable Local Authority rating procedures for independent generators and place them on the same formula basis as the Electricity Supply Industry (via the Rating Review).

Technology Development

9. The programme is currently focussed on those technologies which are approaching commercial exploitation or

have prospects of doing so. The technologies with promise have been developed as follows:

- i. Landfill Gas - Following an initial R&D programme in the late 1970s, demonstrations followed and 33 commercial applications now exist with 75 more planned or under construction. The schemes currently in operation provide .15 mtce of energy and this figure will increase to .55 mtce when the 75 new schemes are complete. R&D is now under way to improve the technology and enhance the resource.
- ii. Passive Solar Design of Buildings - Assessment and design studies followed by monitoring of buildings in the field is now leading to the point where design advice can be offered to the building industry within the next year or two. This programme builds on the fundamental understanding on energy in buildings provided by the SERC's specially promoted programme in this area.
- iii. Wind - Assessment and resource studies have led to the deployment of a range of experimental turbines spanning the likely size range applicable to UK electricity generation for connection to the grid. The UK has one of the

world's leading designs and is about to construct its first experimental wind farms to test public reaction and obtain performance data from medium-sized turbines. The UK also has leading designs at the larger 1 and 3 MW scale. The Department's programme has been supported in areas such as aerodynamics and composite materials by expertise in Higher Education Institutes which has been developed by SERC support programmes. In addition there is a modest SERC applications programmes focussed on developing area for relatively small installations.

- iv. Tidal Barrages - Extensive feasibility studies have been conducted with industry of a range of sizes of estuaries. The technology is known to be feasible and the environmental impact is being assessed. The high initial capital cost of tidal barrages would require their environment advantages to be reflected in the price paid for their output before they could be financed in the private sector. The Department's work has build on the research base in coastal engineering and estuarial flow which has been funded by SERC and NERC.

- v. Geothermal Hot Dry Rock - The UK has the leading expertise in geothermal HDR. However, the technology is proving to be very uncertain and is unlikely to be economic within the next decade or two even if the known technical problems are capable of a solution. The programme is currently under review.
- vi. Wave - The early R&D programme (some of which was funded by SERC) demonstrated that large-scale offshore wave was unlikely to be economic in the UK in the foreseeable future. However, it is probable that at least smaller scale shoreline devices could make a small but economic contribution. The UK has one of the leading world programmes with an experimental prototype being deployed in Scotland.
- vii. Biofuels - Assessment studies, harvesting and combustion trials have been conducted on a range of agricultural and forest wastes and energy crops. These are now on the verge of being economic in some circumstances and require to be demonstrated at full scale in order to prove commercial competitiveness in the future. Use of agricultural, industrial and domestic refuse

as a fuel has also been assessed with combustion and processing trials (the latter has also been supported by SERC and AFRC). In some market sectors they are economic now and are likely to become more competitive in the future as standards of waste treatment have to rise under legislative pressure.

10. Overall, technical development has reached the point in the UK, mainly with UK industry, to enable pre-commercial demonstrations of a number of technologies to take place in the coming decade and if successful the move to full commercial deployment in the later 1990s and post-2000. In other cases (eg landfill gas) this stage is already past and industry is already using the technologies in commercial applications.

Environmental Implications

11. All sources of energy have environmental implications. Those for renewable energy are however in general different to those for conventional sources since their environmental effects are often localised and for some technologies free of gaseous emissions. However, examples of environmental issues of concern are visual and noise intrusion from wind turbines, ecological impacts of tidal barrages and the emissions from refuse incinerators. The R&D programme is assessing the

extent and public reaction to each of the major environmental concerns and ways of mitigating them where necessary.

12. Renewable energy can however make a substantial contribution to reducing greenhouse gas emissions. The direct generators of electricity such as wind and tidal power produce no emissions. Technologies burning biofuels such as wood, agricultural or other waste do not make any net contribution to atmospheric carbon since the carbon dioxide produced in combustion is essentially recycled as new plants and thus grow. Combustion of refuse avoids the anaerobic digestion process which produces the more potent greenhouse gas methane. Combustion of methane from landfill sites as an energy source emits the C02 rather than methane. Application of renewable energy sources to the extent of the estimated contribution in Table 1 would produce a reduction equivalent up to 20% of current C02 emissions in the UK.

Future Development and Application of Renewable Energy Sources

13. The current strategy is intended to remove institutional barriers and conduct the necessary R&D with industry, leading to small-scale demonstration during the 1990s and significant commercial exploitation post-2000. The Non-Fossil Fuel Obligation provisions in the Electricity Act 1989 should afford a degree of necessary market protection to the developing technologies before they are fully competitive and

enable them to be taken up on a modest scale in a commercial environment before they are fully commercially competitive.

14. Such protection has already been provided to a significant degree in the USA, Germany and Denmark, for example, by a mix of direct Government grants, premium prices for electricity from renewables and tax incentives.

Expenditure in other countries on such activities and R&D programmes has been very much greater in many cases than in the UK.

15. The Environment White Paper will re-emphasise the Government's commitment to ensuring that the renewables can play a full part in meeting the environmental challenge in the future. The programme will develop to give more emphasis to promotion and demonstration of the technologies as it moves into a technology transfer phase.

Coal

16. The Department's much smaller coal R&D activities have in the past been framed in the context of the R&D being done by nationalised coal and electricity industries which were obliged under their statutes to agree their R&D programmes with the Secretary of State. The Department's activities have focussed on particular objectives appropriate for Government:

- i. to provide information about technological developments needed by the Department for its oversight of the industry
- ii. to establish, with the industries, options for the longer term for coal's role in the UK energy market - particular concerns have been upgrading of coal into gaseous or liquid fuels and examining ways of using coal in environmentally favourable ways.

Achievements

17. Given the small scale of its activities much of the Department's work has been in collaboration with the coal and electricity industries and where appropriate other bodies at home and abroad. Significant achievements over the last decade include:

- i. development of fluidised bed combustion systems. A major facility was developed with British Coal under an International Energy Agency collaboration with 2 other countries at Grimethorpe in which a pressurised fluidised bed combustion system was developed which achieved significant advances in efficiency and environmental performance (reduction in acid emissions). The system is now being exploited

in a number of countries as one of a range of new clean coal technologies.

- ii. a gasification process (the slagging gasifier) is being developed with British Gas and others at a major facility in Westfield in Scotland. This process, as well as providing a longer term option for the production of synthetic natural gas, can also provide a key element in the new high efficiency combined cycle electricity generation systems which are likely to be installed in the 1990s around the world to achieve high efficiency and low pollution electricity generation from coal.
- iii. advances in the basic science of coal combustion (including development of novel techniques of laser diagnostics developed originally for hydrocarbon combustion). This work underpins the development of low NOx burners currently being installed in UK power stations to meet new emission standards.

In addition the programme has provided information about other coal technology (including mining and production) which the Department has used in its oversight of the coal industry and its investment. The SERC has also provided support for the higher education sector to maintain a capability on coal

combustion science and extraction and is reviewing with the Department its approach in the area.

18. As in the case of renewables the Department participates fully in international coal R&D activities both in the International Energy Agency (which provided the framework for the fluidised bed combustion collaboration referred to above) and the European Community where officials have supported UK applications for funding from Community R&D schemes (eg for British Coal's coal liquefaction plant at Point of Ayr).

19. In many other countries Government R&D expenditures on coal are significantly larger than in the UK. Table 2 sets out figures for a number of countries and relates these to coal consumption and production. These expenditures provide in general, substantial support for indigenous private sector coal producers. Annex 2 summarises information about government Coal R&D programmes in the countries concerned.

Future R&D activities

20. The privatisation of the ESI and increasing environmental pressures and constraints on the use of coal for electricity generation have major implications for the development of clean coal technologies. The Department has therefore initiated a major review of its coal R&D programme with the intention of developing a long term R&D strategy in collaboration with British Coal and UK industry. The future

programme will aim to improve the economics and environmental impact of exploiting the substantial UK coal resource and give the Department appropriate information about long term developments in the industry.

21. With the forthcoming privatisation of the industry there will be a greater need for knowledge about reserves and mining potential in order to permit the Department to oversee exploitation of coal reserves by private sector companies. The private sector successors to British Coal will be less inclined to invest in long term R&D on coal combustion, and there may be a need for Government involvement in such R&D to underpin our continuing access to energy from the UK's coal resources. In countries such as Australia and the Federal Republic of Germany with large private sector coal industries, much of the long term R&D is funded by government with the industry supporting short term work.

22. Increasing concern about the environment is also likely to lead to continuing activity in supporting clean coal technology (such as the topping cycle project for which the Government has offered British Coal support). In view of concern about C02 emissions and the greenhouse effect, there is also likely to be a need for longer term research into ways of capturing C02 and disposing of it other than in the atmosphere - British Coal is exploring international interest in R&D in this area and the Department may need to play a

role in collaborative work. Research to reduce releases of and utilise colliery methane would also form part of future work on the greenhouse effect.

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ANNEX 1: EXPENDITURE BY DEPARTMENT OF ENERGY ON RENEWABLES AND
COAL R&D

	£m.	
	Renewables	Coal
1979/80	8.2	-
1980/81	11.3	2.7
1981/82	17.3	4.6
1982/83	14.7	3.0
1983/84	11.7	3.0
1984/85	14.9	0.7
1985/86	13.2	0.6
1986/87	12.0	1.6
1987/88	15.1	1.2
1988/89	16.0	0.7
1989/90	17.9	1.7

ANNEX 2

COAL RESEARCH AND DEVELOPMENT OUTSIDE THE UNITED KINGDOM

Figures for Government spending are set out in Table 2 (attached)

Japan

It is expected that coal, mainly imported, will represent about 10% of the country's primary energy requirements in 2000 and that this contribution will be based on the clean use of coal as part of Japan's "high" technology intensive energy economy" for the 21st century. To support this Japan funds projects on clean and efficient coal use and coal conversion.

United States

Coal consumption in the USA is expected to increase by 3% per annum to 2000 and priority has been given to developing new technologies to burn coal with low emissions and in smaller applications. A large element of the coal R,D&D work is the Clean Coal Demonstration Programme which is based upon joint Government-industry funding to develop promising clean coal technologies. The total Government commitment to this programme by 1992 is expected to reach \$2.5 billion. Up to the end of 1988, 29 projects had been approved with a total appropriation of \$975 million.

Federal German Republic

Much of the German programme is concerned with the clean use of coal, and gasification research for combined cycle power generation is an important element. Support is also provided for mining technology. Environmental pressure is likely to mean continued priority for funding coal R&D.

Canada

Coal is regarded in Canada as a longer term option to substitute for oil or gas. The R&D programme was reviewed in 1988, and initiatives of C\$81 million have been identified for R,D&D on coal-oil slurry pipelines, increased coal beneficiation, and enhancement of combustion characteristics. It is intended that the cost of this should be shared between Governments and industry.

TABLE 2

1988 DIRECT GOVERNMENT R,D&D EXPENDITURE ON COAL

Country	Japan	USA	FRG	Canada	UK (88/89)
Coal produced m tonnes	9	718	104	52	104
Coal consumed m tonnes	105	656	106	40	109
Total direct Govt expenditure \$ million	308	239	100	22	1.4
Govt expenditure on production R,D&D \$ million	11	49	23	8	-
Govt expenditure on utilisation R,D&D \$ million	297	190	77	16	1.4
Total expenditure per tonne coal produced cents/tonne	3400	33	96	42	1
Total expenditure per tonne coal consumed cents/tonne	290	36	94	55	1
Expenditure on coal utilisation R,D&D per tonne coal consumed cents/tonne	280	30	70	40	1

Notes:

1. Source: DEn for UK figures. All other data ex IEA.
2. Figures for UK Government support exclude funding by the NI's.
3. dollars are 1988 US \$.